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THE USE OF STRICTLY DEFINED TERMS IN SUMMERTIME FORECASTS

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ABSTRACT

The desirability of using a fixed set of strictly defined terms to describe the areal distribution of summertime showers and thunderstorms in the daily State forecast is discussed, and the feasibility of doing so is investigated. The areal distribution of afternoon and evening showers in Colorado and the variations of the distributions among various sections of the State are determined. The relative frequency of occurrence of forecast categories is determined for two sets of arbitrarily defined forecast terms. Significant differences are found, on the average, in the number of showers when various forecasting terms are used to describe their occurrence.

A simple objective aid for forecasting the areal distribution of showers over the entire State of Colorado is presented to illustrate that there are meteorological variables that are related to the number of showers expected over an area which could form the basis for forecasts stated in strictly defined terms.

1. INTRODUCTION

The advocating of the use of and adherence to qualifying terms in forecasts which have definite meanings to describe the areal distribution of summertime shower activity is by no means new. Strictly defined terms have been used by the U. S. Weather Bureau in the Southeastern States in issuing shower and thunderstorm forecasts for use in cotton-spraying activities with apparently good success, and specific terms with definite definitions in terms of the percentage of area expected to be affected by showers are used for aviation forecasts. These two sets of terms are listed in tables 1 and 2 for comparison purposes.

As can be seen, the percentage definitions are for practical purposes identical. It can surely be assumed that if no showers or thunderstorms are forecast, the verifying definition under the aviation forecast terms should be 0 percent. The term "numerous" in the aviation list corresponds to the last two terms combined in the State list. For various reasons the author prefers the terminology used in the aviation list (with the term "none"

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TABLE 1.—*Aviation forecasting terms for describing the areal distribution of showers and thunderstorms*

Term	Percent of area expected to be affected
Few	Less than 15.
Widely scattered	15 to 30.
Scattered	31 to 45.
Numerous	Greater than 45.

TABLE 2.—*Forecasting terms for describing the areal distribution of showers and thunderstorms used in forecasts for cotton-spraying operations in the Southeastern States*

Term	Expected percent of areal coverage to receive measurable precipitation
Fair or partly cloudy with no mention of precipitation	0
Risk (or chance) of showers	0–15
Widely scattered showers	15–30
Scattered showers	30–45
Showers	45–75
General showers (or rain)	75–100

added), and this list will be used in the following sections on the investigation of the areal distribution of showers in Colorado and the "verification" of forecasts issued in the past. The reasons for this preference may be correctly classified as personal opinion and need not be discussed here. Arguments about the relative merits of various terms for describing shower and thunderstorm activity could be, and are, carried on endlessly. Actually, it is relatively immaterial what *words* are used in such a list, the only criterion being that the terms imply a progressive increase in the areal coverage by shower activity. The important things are the percentage definitions of the terms and the strict adherence to the terms once they are decided upon and defined.

One purpose of this study is to reemphasize the desirability of using such a list in the State, or general, forecasts and to point out the necessity of determining the relative frequency with which the various terms should be used. These frequencies will vary with climatologically different regions, and therefore, should be determined for climatological regions, if not for the individual States. This study applies only to the State of Colorado and no attempt should be made to apply the results to other regions. Very similar results would undoubtedly be obtained for any of the States straddling the Continental Divide, however, and the results obtained for the lower elevations of Colorado may prove typical for the Plains States.

In addition to stressing the desirability of using a fixed set of strictly defined terms to describe summertime shower activity, this study points out the feasibility of doing so. Comparison of the more commonly used terms in the daily forecasts issued for Colorado with the daily areal distribution of showers shows that on the average there are significant differences in the number of showers when the different terms are used. Stated in another way, forecasters show skill in describing the areal distribution of showers and thunderstorms. A simple objective aid will be described in section 5, which illustrates that such forecasts, at least for an entire State, can be placed on a quantitative and objective basis.

In line with the above discussion, the specific objectives of this study may be stated as follows: 1. To determine the areal distribution of afternoon and evening showers in Colorado and the variations of the distributions between various sections of the State. 2. To set up specific limits or definitions for various forecast terms to describe the distribution of showers, or alternatively, to determine the relative frequency of occurrence of forecast categories if arbitrary limits are established to define the categories. 3. To determine if there were any significant differences in the number of showers when various forecasting terms were used to describe their occurrence during the period under study.

2. AREAL DISTRIBUTION OF SHOWERS IN COLORADO

The precipitation data used in the investigation were obtained from the hourly precipitation amounts in Colorado published by the U. S. Weather Bureau for July and August of 1951–54. The number of reporting stations used varied during these 8 months from 81 to 87. Any station which did not show a complete record for the entire month was eliminated.

The State was divided into four equal sectors (Northwest, Northeast, Southwest, and Southeast) by a line along the 105.5° W. meridian and a line along the 39th parallel of latitude. All stations which reported precipitation (0.01 inch or more) between the hours of 11 a. m. and midnight (MST) were counted for each day in each sector and converted into a percentage by division by the total number of stations utilized in each sector. These percentages shall hereafter be referred to as the *daily percentages*. To obtain the daily percentages in the East half of the State, it was then only necessary to add the number of stations reporting precipitation in the Northeast and Southeast quadrants and divide by the total number of stations in these two quadrants. Similarly, daily percentages were obtained for the West, North, and South halves of the State and for the entire State.

A further division of the State was made into Mountain areas and Lower Elevation areas. This division was somewhat arbitrary, but it is felt it serves the purpose adequately. The general criteria used to decide if a station were a Mountain station or a Lower Elevation station were: 1. East of the Divide all stations whose elevations are 6,000 feet or higher were considered Mountain stations. 2. West of the Divide all stations whose elevations are 7,000 feet or higher were considered Mountain stations. There were four major exceptions to this rule, namely: Monte Vista, Alamosa, and San Luis in the high, broad San Luis Valley, which is above 7,000 feet MSL, were listed with the Lower Elevation stations, while Eagle (elevation 6,497 feet), which is in a rather narrow canyon, was listed as a Mountain station. These divisions of the State are illustrated in figure 1, with the cooperative reporting stations utilized marked by a solid triangle.

Cumulative frequency distributions of the daily percentages were computed for the entire State, the East, West, North, and South halves of the State, and for the Mountain and Lower Elevation sectors. Figure 2 shows the cumulative frequency curves of the daily percentages for the North and South sectors, figure 3 for the East and West sectors, and figure 4 for the Mountains and Lower Elevations, and for the entire State.

There is apparently no significant difference between the distributions for the North and South halves of the State. The distribution of the daily differences in the daily percentages between the two portions of the State is shown in figure 5. This distribution seems to be very nearly normal with a mean difference of 0 percent and a standard deviation of about 15 percent. (Actual mean of distribution is −1 percent, and the standard deviation 14.5 percent.) The normality of this distribution and the zero mean would imply that there is no climatological difference in the density of shower activity between the North and South halves of the State in summer.

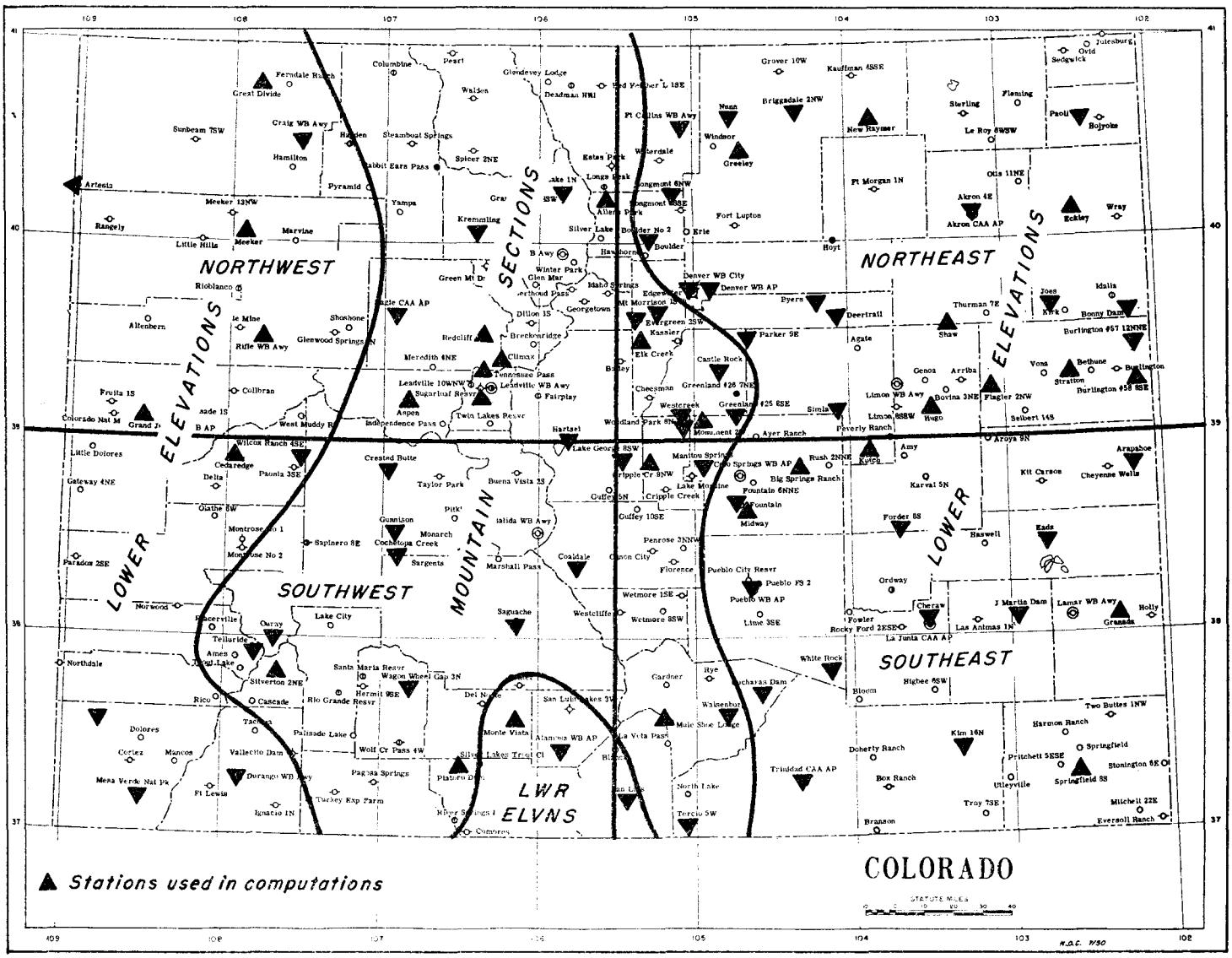

FIGURE 1.—Map showing division of State of Colorado into various sections and the Weather Bureau cooperative stations used to obtain precipitation data.

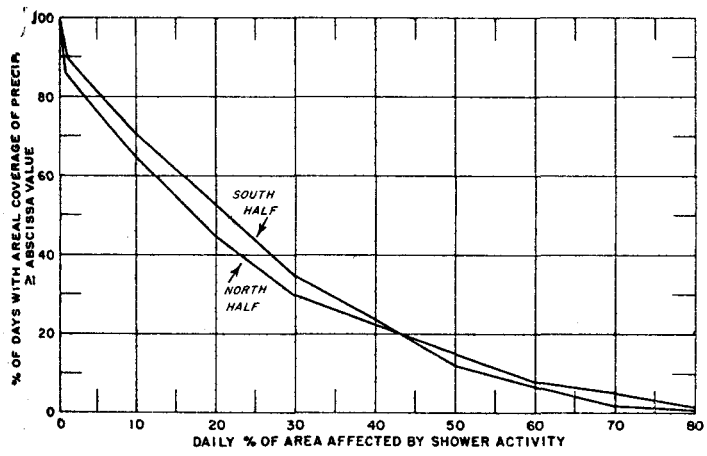

FIGURE 2.—Cumulative frequency curves of the daily percentages of area affected by showers and thunderstorms for the North and South halves of the State of Colorado.

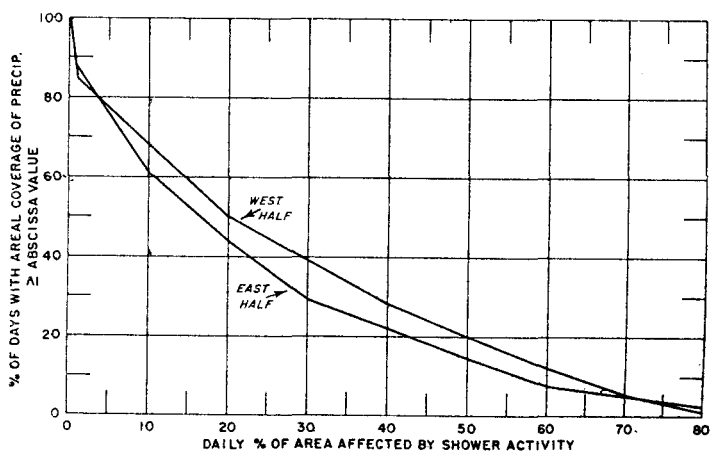

FIGURE 3.—Cumulative frequency curves of the daily percentages of area affected by showers and thunderstorms for the East and West halves of the State of Colorado.

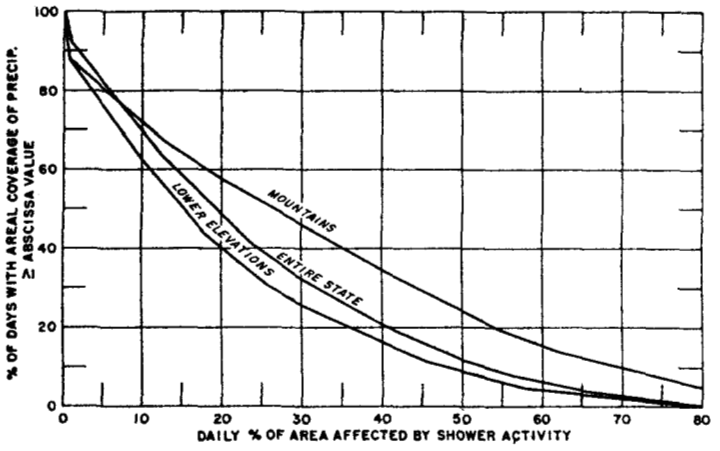

FIGURE 4.—Cumulative frequency curves of the daily percentages of area affected by showers and thunderstorms for the Mountain and Lower Elevation sectors, and the entire State of Colorado.

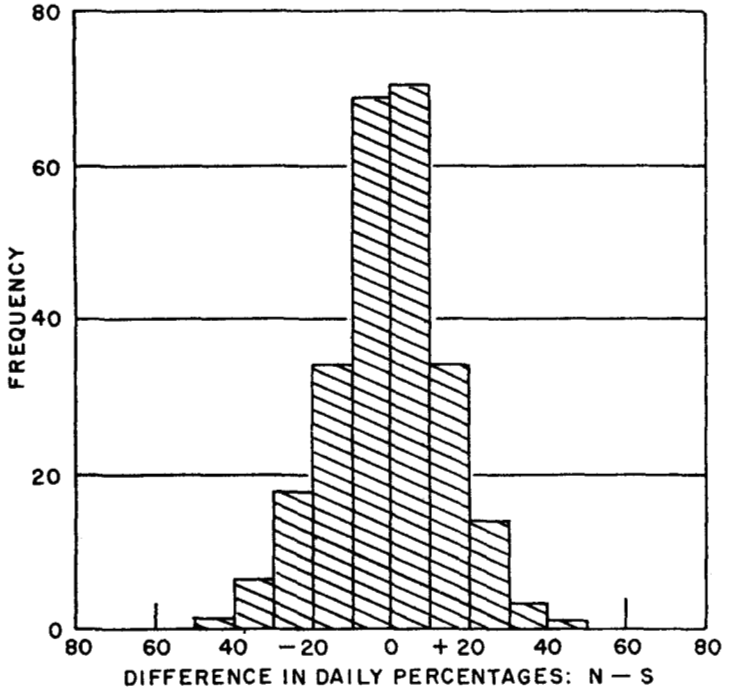

FIGURE 5.—Frequency distribution of the daily differences in the daily percentages of area affected by showers in the North and South halves of the State of Colorado.

In figure 3, the cumulative frequency curves show a somewhat greater difference between the distributions of the daily percentages for the East and West portions of the State than there is between the North and South halves. The distribution of the daily differences in the daily percentages is shown in figure 6. The mean of this distribution is +3.4 percent and the standard deviation 21 percent, indicating that on the average there is a slightly greater density of showers west of the Divide than east of the Divide and that there are more days with large differences in shower activity between the West and East than between the North and South. (The mean of +3.4 percent is significantly different from 0 percent at the 0.02 level.)

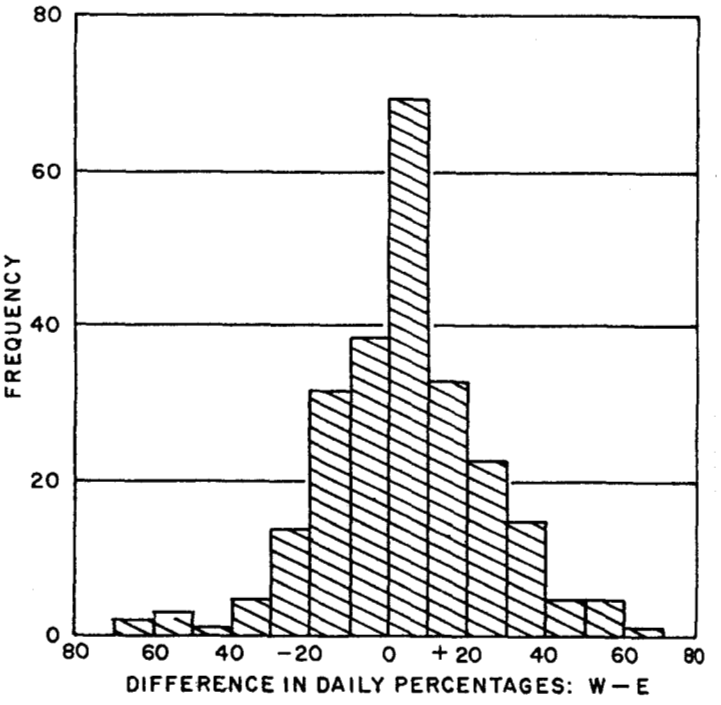

FIGURE 6.—Frequency distribution of the daily differences in the daily percentages of area affected by showers in the East and West halves of the State of Colorado.

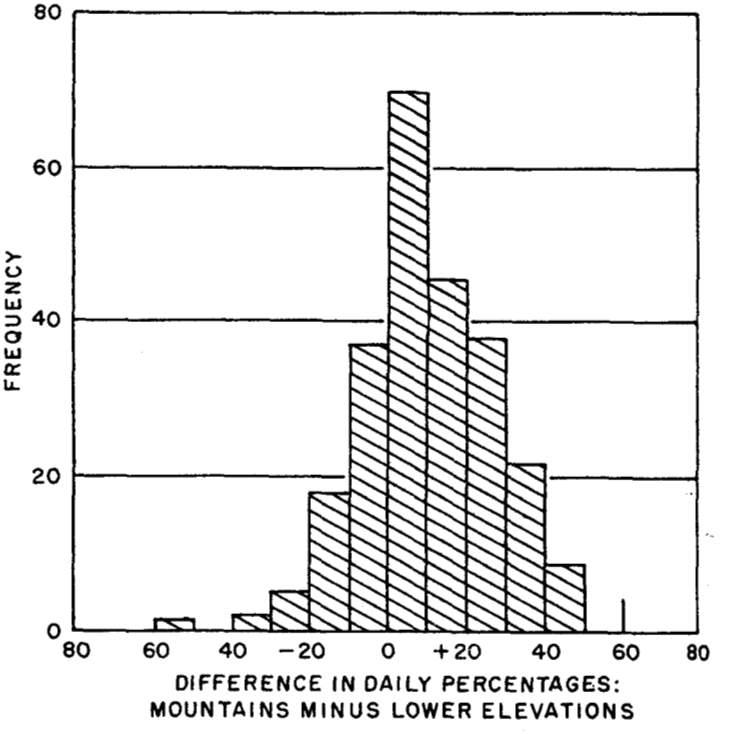

FIGURE 7.—Frequency distribution of the daily differences in the daily percentages of area affected by showers in the Mountains and Lower Elevations of the State of Colorado.

It will surprise no one, of course, that the greatest difference in the areal distribution, or density, of shower activity in Colorado is with elevation. The cumulative frequency curves for the Mountain stations and the Lower Elevation stations shown in figure 4 are quite different. The distri-

bution of the daily differences in the daily percentages in these two regions is shown in figure 7, with a mean of +9.4 percent and a standard deviation of 16.8 percent. This mean is highly significantly different from 0 percent.

3. DEFINITION OF FORECAST TERMS

There are two courses open for defining forecasting terms to describe the areal distribution of summertime showers: 1. The terms may be defined so that the class intervals of the daily percentages are equally likely to occur, in which case the class intervals defining the terms would all be different. Furthermore, the class intervals defining the terms would have to be different for different climatological sectors such as the Mountains and Lower Elevations of Colorado. 2. The terms may be defined using arbitrary equal class intervals of the daily percentages and then the relative frequency of occurrence of each term may be determined. In this case the relative frequencies of occurrence of the terms, or classes of daily percentages, would be different from each other, and, in addition, would be different for two climatologically different sections.

There might be some advantage to the forecaster if the terms were defined under the first alternative since the terms would have an equal likelihood of occurrence, but definitions under this alternative would be highly confusing to the user of the forecast. In addition, definition of the terms under this alternative would result in class intervals of the daily percentages for several of the terms too small to be practical. For example, let the following five terms be selected to describe the shower activity: None, Few, Widely Scattered, Scattered, and Numerous, and let their relative frequency of occurrence be 20 percent each. From the cumulative frequency curve for the Lower Elevations shown in figure 4 the class intervals of daily percentage to define these terms shown in table 3 would be obtained. Obviously, the intervals of 4 to 11 percent and 12 to 20 percent are too small for practical purposes, and 35 percent seems to be rather low for the lower limit of "numerous" showers.

If the forecasting terms are defined under the second alternative, the class intervals of the daily percentages can be arbitrarily chosen and the terms can apply to any section of the country. It would certainly behoove the forecaster, however, to be aware of the relative frequency of occurrence of the various terms in the particular section for which he is forecasting. Two such lists of terms with practically identical definitions in terms of the percentage of area [2] expected to be affected by showers and thunderstorms are listed in tables 1 and 2. As stated in the introduction the aviation list is preferred, and this list, with the term "none" added, is repeated in table 4 with the indicated definitions in terms of the areal coverage of showers. The addition of "none" to the list alters the definitions of the "few" and "widely scattered" terms by 1 percent, but actually equalizes the class intervals defining the three middle terms.

Now, a priori, it would seem that for such a list to be reasonable, the extremes, namely the "none" and "numerous" terms, should have the smallest frequencies of occurrence. When these definitions are applied to the cumulative frequency curves for the Mountains and Lower Elevations shown in figure 4 the climatological frequencies of occurrence for each term shown in table 5 are obtained. As can be seen, judged on the criterion that the extreme terms should have the smallest frequencies, the "numerous" term is considerably out of line for the

TABLE 3.—*Class intervals of daily percentages of area affected by showers required for definition of terms for the Lower Elevations of Colorado when each term is allowed to have an equal likelihood of occurrence*

Term	Frequency of occurrence	Class interval of daily percentage
	Percent	
None	20	<4
Few	20	4–11
Widely scattered	20	12–20
Scattered	20	21–35
Numerous	20	>35

TABLE 4.—*Modified list of aviation forecasting terms for describing the areal distribution of showers and thunderstorms*

Term	Percent of area expected to be affected
None	0
Few	1–15
Widely scattered	16–30
Scattered	31–45
Numerous	>45

TABLE 5.—*Climatological frequencies of occurrence of forecasting terms defined by a 15-percent class interval of areal coverage of showers. (Mountains and Lower Elevations of Colorado)*

Term	Defining percentage	Percent frequency of occurrence	
		Mountains	Lower elevations
None	0	12	12
Few	1–15	24	38
Widely scattered	16–30	18	25
Scattered	31–45	17	13
Numerous	>45	29	12

TABLE 6.—*Climatological frequencies of occurrence of forecasting terms defined by a 20-percent class interval of areal coverage of showers. (Mountains and Lower Elevations of Colorado)*

Term	Defining percentage	Percent frequency of occurrence	
		Mountains	Lower elevations
None	0	12	12
Few	1–20	30	48
Widely scattered	21–40	24	24
Scattered	41–60	19	12
Numerous	>60	15	4

[2] It is assumed in this study that the percentage derived from the ratio of the number of stations reporting precipitation to the total number of stations is a reasonable estimate of the percentage of area affected by shower activity. While this assumption is open to question since the stations are far from uniformly distributed, it is the only such estimate available.

TABLE 7.—*Climatological frequencies of occurence of forecasting terms defined by a 15-percent class interval of areal coverage of showers. (Entire State of Colorado)*

Term	Defining percentage	Percent frequency of occurrence
None	0	7
Few	1–15	35
Widely scattered	16–30	26
Scattered	31–45	16
Numerous	>45	16

TABLE 8.—*Climatological frequencies of ocurrence of forecasting terms defined by a 20-percent class interval of areal coverage of showers. (Entire State of Colorado)*

Term	Defining percentage	Percent frequency of occurrence
None	0	7
Few	1–20	45
Widely scattered	21–40	27
Scattered	41–60	15
Numerous	>60	6

Mountains and even at Lower elevations the frequency for "numerous" is practically the same as for "scattered".

This situation can be remedied by defining the terms by a larger interval, say 20 percent rather than 15 percent. If this is done, the definitions and frequencies of occurrence shown in table 6 are obtained. With these definitions the "none" and "numerous" terms have the least frequencies of occurrence. Another advantage of using the 20-percent interval for definition is that the approximate midpoint of each term falls on a percentage that is a multiple of 10, and therefore is more easily remembered. "Scattered" for instance, would mean that on the average 50 percent of the area would be affected by showers.

To obtain an estimate of the relative frequencies of the terms for sections of the State in which both Mountain and Lower Elevation stations are included, the cumulative frequency curve of the daily percentages for the entire State was used. Applying the definitions of the forecasting terms to this curve, shown in figure 4, the frequencies shown in tables 7 and 8 are obtained. It will be noted that when the definitions are based on the 15-percent interval the frequency of occurrence of the "numerous" category is equal to the "scattered" category.

4. COMPARISON OF FORECAST TERMS WITH DAILY PERCENTAGES

The daily forecasts for "this afternoon and evening" which are released at 0830 MST were inspected and the qualifying terms used to describe the afternoon and evening shower and thunderstorm activity were tabulated. The list of terms encountered in this forecast during the 8 months under study, with the number of times each was used, is shown in table 9. The total of the terms used exceeds the number of days (248) because more than one term was sometimes used in the same forecast. This is

TABLE 9.—*List of qualifying terms used to describe expected shower activity "this afternoon and evening" encountered in the forecast for the State of Colorado which is released at 0830 MST. (July and August 1951–54, inclusive)*

Forecast term	Frequency of use
None (this term is never used specifically, but is implied when showers or thunderstorms are not mentioned in the forecast)	45
Few	6
Few isolated	36
Few widely scattered	29
Few scattered	16
Few local	1
Few scattered local	2
Widely scattered, isolated	1
Widely scattered	84
Scattered	65
Occasional showers	2
Showers and thunderstorms (no qualifying term)	2

TABLE 10.—*Forecasting terms used to compare with the observed daily percentage of areal coverage of showers*

Forecast term	Frequency of use
None	45
Few isolated	42
Few widely scattered	29
Few scattered	16
Widely scattered	84
Scattered	65

cially true of the "none" forecasts. There were only days on which no showers or thunderstorms were mentioned for the entire State, but on 27 days the forecast designated certain portions of the State to receive showers, implying none for the rest of the State; thus the total number of "none" forecasts is increased to 45.

For comparison with the observed daily percentages, only those terms with an appreciable frequency were utilized. The six cases of "few" were considered as having the same meaning as "few isolated" and included with the latter term. The other low frequency terms were ignored. This left the terms listed in table 10 to compare with the observed daily percentages.

The daily percentages were tabulated under one of the terms depending upon which term was used to describe the shower activity. If the forecast was for the entire State, the percentage for the entire State was used for verification. If the forecast designated certain portions of the State, the percentages in those portions were used. For example, if a forecast read: "Scattered afternoon and evening showers and thunderstorms Northeast," the percentage for the northeast was listed under the "scattered" category and the percentage for the balance of the State was computed and listed under the "none" category.

Cumulative frequency distributions of the daily percentages were then made for each of the six terms listed in table 10. The unsmoothed curves representing these cumulative frequency distributions are shown in figures 8 and 9, with the curves for "none," "few isolated" and "scattered" on figure 8, and the curves for "few scattered," "few widely scattered," and "widely scattered" in figure 9. It is obvious that there are no significant differences among the three curves in figure 9, and that the three terms are

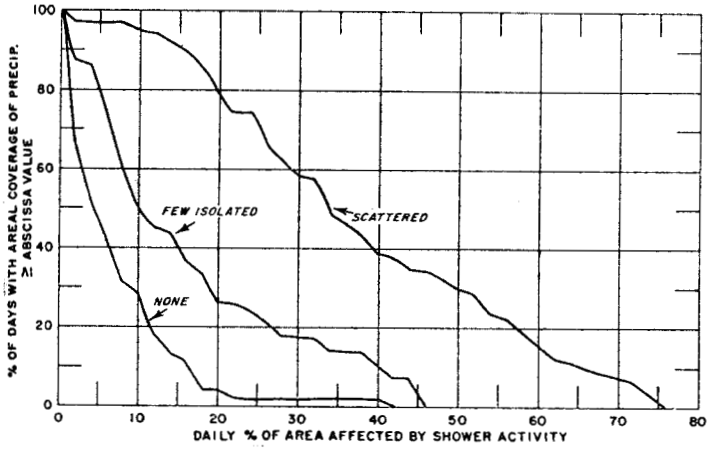

FIGURE 8.—Cumulative frequency curves of the daily percentages of area affected by showers and thunderstorms when the indicated forecasting terms were used to describe the shower activity expected.

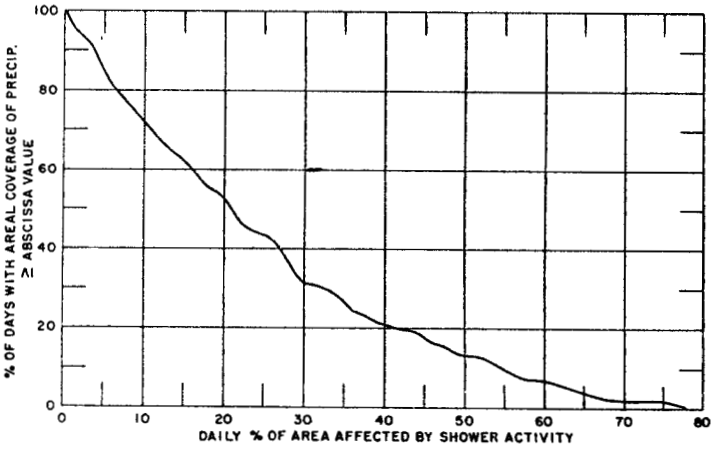

FIGURE 10.—Cumulative frequency curve of the daily percentage of area affected by showers and thunderstorms for the terms "few scattered," "few widely scattered," and "widely scattered" combined.

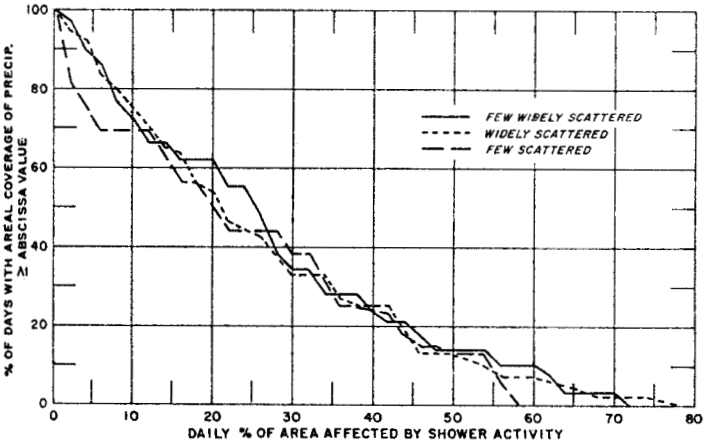

FIGURE 9.—Cumulative frequency curves of the daily percentages of area affected by showers and thunderstorms when the indicated forecasting terms were used to describe the shower activity expected.

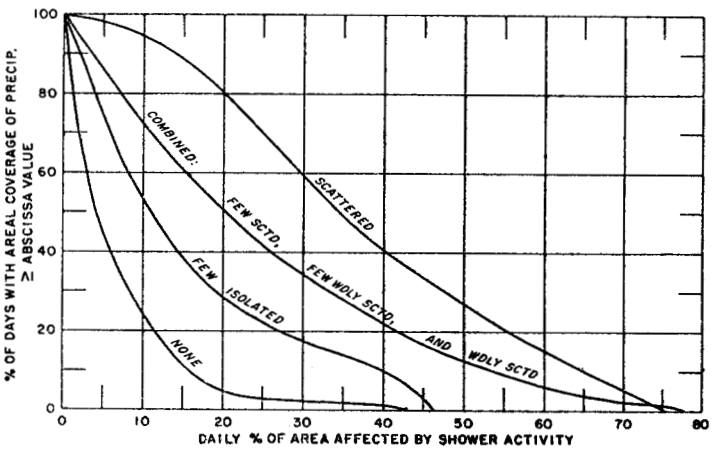

FIGURE 11.—Smoothed cumulative frequency curves of the daily percentage of the area affected by showers and thunderstorms when the indicated forecasting terms were used to describe the shower activity expected.

either synonymous in the forecaster's mind, or if a distinction does exist, it is too fine to be practical. The frequencies of the daily percentages under these three forecast terms were therefore combined into one distribution which is shown in figure 10. Smooth curves were drawn by eye to fit the rough curves in figures 8 and 10, and are shown in figure 11.

TABLE 11.—*A number of statistical parameters obtained from the four distributions shown in figure 11*

	Forecast term			
	None	Few isolated	Combination of "widely scattered," "few widely scattered," and "few scattered"	Scattered
Number of cases	45	42	129	65
Mean	6	15	25	37
Median	4	10.5	20	34
Range	0–41	0–45	0–76	0–72
Standard deviation	7.6	13.4	17.3	19.0

In table 11 are a number of statistical parameters derived from the four distributions. Tests of the differences between the means of these distributions show that the differences are all statistically significant.

While a verification of the forecasts on the basis of the arbitrary equal class intervals defined in the preceding section may not be entirely fair since the forecasters did not necessarily have in mind these particular limits when the forecast was made, such a verification is of interest, nonetheless. The contingency tables derived from the verification of the forecasts on the basis of the two sets of definitions in the preceding section are shown in tables 12 and 13. The term "numerous" was never used during the 8 months involved in this study, and while "showers and thunderstorms" without any qualifying terms can be considered equivalent to "numerous," such forecasts were made only twice and it would hardly be fair to the forecasters to include this category in this verification since daily percentages of greater than 45 percent occurred 31 times at lower elevations and as high as 68 times in the

TABLE 12.—*Verification of forecasts on basis of definitions of terms based on a 15-percent class interval of areal coverage of showers*

		FORECAST					
		None	Few isolated	Widely scattered*	Scattered	Total	
OBSERVED	None, 0 percent	13	5	7	2	27	Skill score: 0.18
	Few, 1–15 percent	27	22	42	5	96	
	Widely scattered 16–30 percent	4	8	36	20	68	Percent correct: 39
	Scattered, >30 percent	1	7	44	38	90	
	Total	45	42	129	65	281	

*Includes "few widely scattered" and "few scattered."

TABLE 13.—*Verification of forecasts on basis of definitions of terms based on a 20-percent class interval of areal coverage of showers*

		FORECAST					
		None	Few isolated	Widely scattered*	Scattered	Total	
OBSERVED	None, 0 percent	13	5	7	2	27	Skill score: 0.15
	Few, 1–20 percent	31	26	56	14	127	
	Widely scattered, 21–40 percent	0	7	37	24	68	Percent correct: 36
	Scattered, >40 percent	1	4	29	25	59	
	Total	45	42	129	65	281	

*Includes "few widely scattered" and "few scattered."

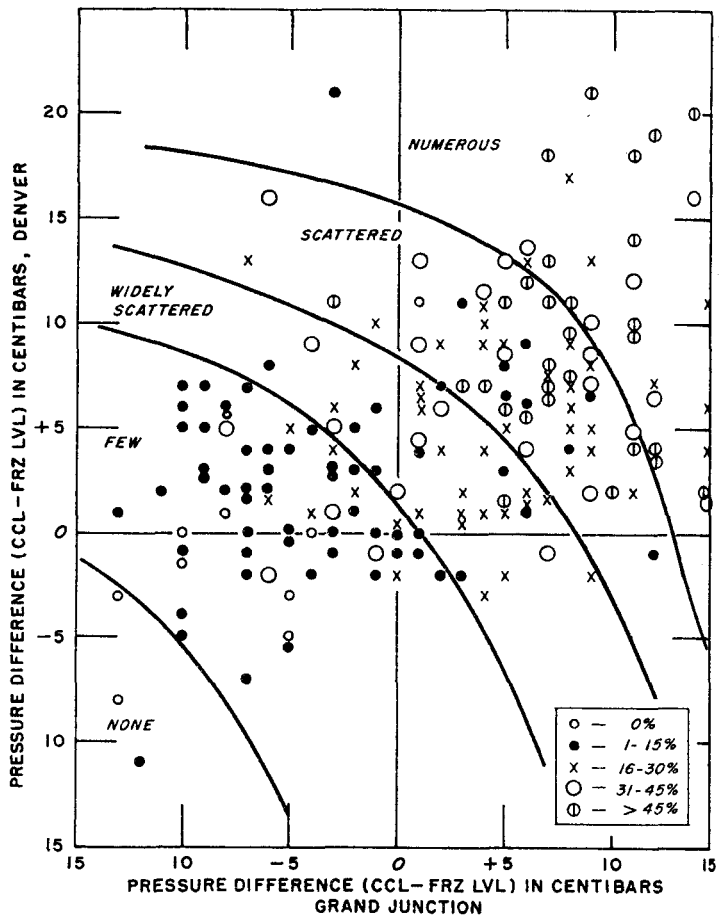

FIGURE 12.—Joint relationship between the pressure difference convective condensation level minus freezing level (CCL—FRZ LVL) at Denver and Grand Junction, Colo., and the daily percentage of area affected by shower activity in Colorado. Class intervals of daily percentages are represented by symbols.

mountains. The term "scattered" is, therefore, verified by any percentage greater than 30 percent and greater than 40 percent, respectively, in the two tables. The term "few isolated" used so consistently in the forecasts was considered synonymous with "few" in the definitions.

The verification by the 15-percent interval definitions seems to show a slight advantage on this series of forecasts, but the difference is probably not significant. The fact that skill is shown in these forecasts indicates that it is highly probable that the skill score would have been considerably greater if either of these sets of definitions had been in the minds of the forecasters, and especially if the forecasters had been aware of the relative frequency of occurrence of the various terms. As can be seen, for instance, the "widely scattered" term (or its equivalent "few widely scattered" or "few scattered") was used out of all proportion to its actual frequency of occurrence and the term "few" ("few isolated") not often enough under either set of definitions. It cannot be concluded, however, that these terms were actually used "too often" or "too little" since the defining percentages were applied to the forecasts after they were made. It tends to stress, however, one of the main points of this paper, namely: no one knows, including the forecasters themselves, exactly what is implied by the forecast terminology in terms of the areal coverage of shower activity, or the relative probability of being rained on.

5. AN OBJECTIVE AID

Defining a list of forecasting terms is one thing; the ability to differentiate between the daily areal coverage of shower activity (or more precisely to differentiate between the daily percentages of stations affected by showers) is quite another. The definitions should not be primarily dependent upon the forecaster's ability to differentiate between them, but it is apparent that they must be to a certain extent. For instance, it would not be practical to have too long a list which would necessitate a small class interval of percentage for definition. Percentage definitions of any sort would be useless unless there is evidence that skill exists, or potentially exists, in making such differentiations. Such evidence has been presented in the preceding sections by illustrating that significantly different distributions of the daily percentages are obtained for the more commonly used terms, and by showing that positive skill results when arbitrary percentage definitions of terms are applied to a series of forecasts that were not necessarily based on the definite limits involved in the definitions.

As further evidence that the differentiation might be made with reasonable accuracy, and in fact might be placed on a more sound, quantitative basis, a simple objective method is described below. This is by no means an exhaustive study of the problem, but is presented

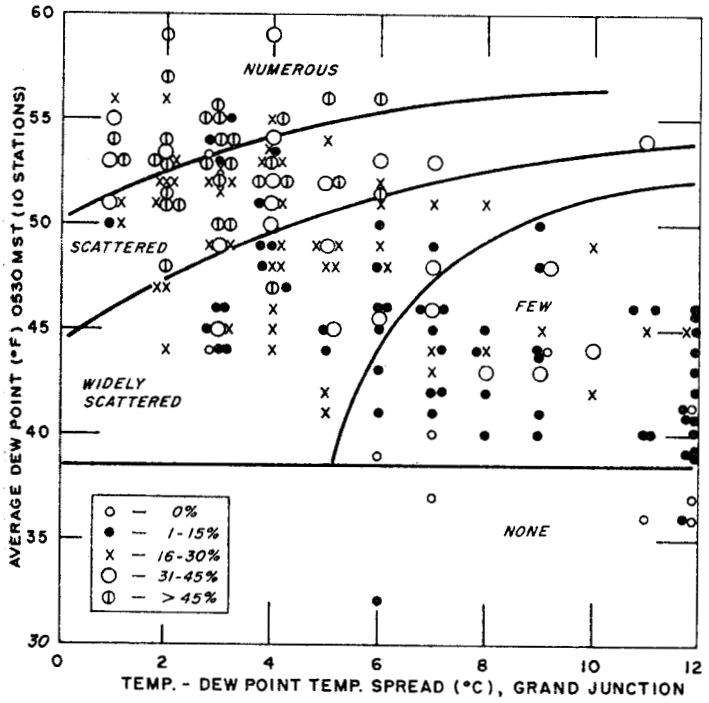

FIGURE 13.—Joint relationship between the minimum dew point spread in the 700–500-mb. layer at Grand Junction and the average surface dewpoint temperature in the State and the daily percentage of area affected by shower activity in Colorado. Class intervals of daily percentages are represented by symbols.

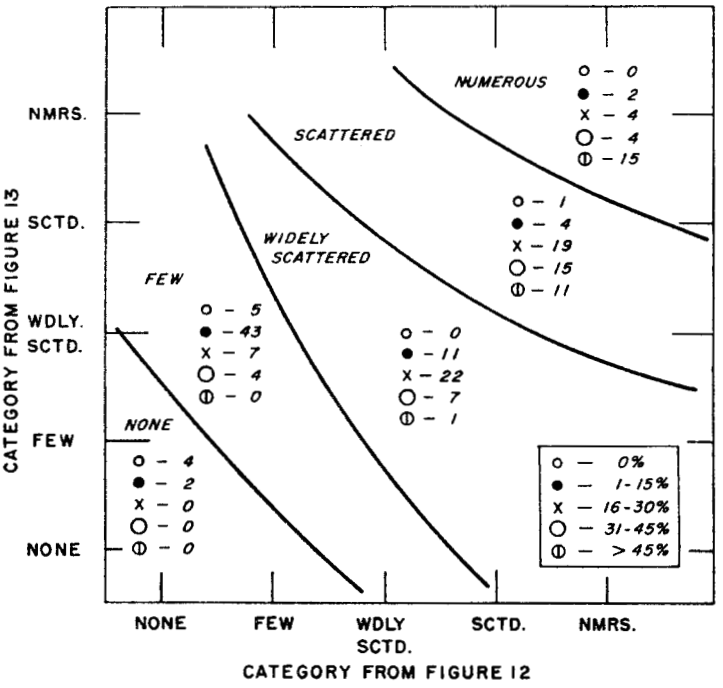

FIGURE 14.—Joint relationship between categories from figures 12 and 13 and the daily percentages of area affected by shower activity in Colorado.

merely to show that certain meteorological variables that have been found to be related to the occurrence or nonoccurrence of shower activity at particular localities are apparently also related to the number of showers over an area. This aid is based on only 6 summer months (July and August 1951, 1952, and 1954), and has not been tested on independent data, and in addition, applies to the entire State. The results are encouraging, however, and such a study should be a definite aid in deciding which strictly defined term to use to describe the areal distribution of showers on a given day.

Four variables were combined graphically and related to the observed daily percentages for the entire State of Colorado. These variables were:

1. Difference in pressure (in centibars) between the convective condensation level and the freezing level at Grand Junction, Colo. (CCL minus FRZ LVL).
2. Same as 1 for Denver, Colo.
3. Minimum spread between the temperature curve and the dew point temperature curve in the layer 700–500 mb. at Grand Junction, Colo.
4. Average of surface dewpoint temperatures at 10 stations in Colorado (or very near the border). (Grand Junction, Craig, Leadville, Alamosa, Trinidad, Pueblo, Denver, Akron, and Lamar, Colo., and Farmington, N. Mex.)

These variables were based on, or computed from, the 0530 MST surface observations and the 2000 MST upper-air soundings of the previous evening. In computing the convective condensation levels at Grand Junction and Denver, the 0530 MST surface dewpoint temperature at each of the two stations was used in conjunction with the 2000 MST upper-air sounding of the previous evening. The freezing level was taken from the 2000 MST sounding.

The daily percentages were not plotted on the charts as such, but instead symbols were used to represent class intervals of the percentages corresponding to the 15-percent class interval definitions of forecasting terms. These symbols are listed within each chart.

Figure 12 shows the joint relationship between the pressure differences (CCL minus FRZ LVL) at Grand Junction and Denver and the daily percentages. The chart was divided into five regions in which, as nearly as possible, the frequency of occurrence of one symbol (or class interval of percentage) was greater than the rest. The regions were then labeled "none," "few," etc., according to the dominant symbol or class interval.

A similar analysis was performed on figure 13 relating the other two variables to the daily percentages. Categories from these two charts were obtained for each case and used as coordinates of figure 14. The individual symbols are not plotted on this chart since a large number of cases fall at the discrete points determined by the categories used as coordinates. The distributions of the symbols in the regions indicated on the chart are listed, however, to show the stratification achieved.

Table 14 is a comparison of "forecasts" obtained from figure 14, and the observed percentages, and indicates a skill score of 0.40. It will be noted that this is a 5 by 5 contingency table, with the term "numerous" included,

TABLE 14.—*Verification of "forecasts" made by the objective aid on developmental data. (July and August 1951, 1952 and 1954)*

		FORECAST						
		None	Few	Widely scattered	Scattered	Numerous	Total	
OBSERVED	None, 0 percent	4	5	0	1	0	10	Skill score: 0.40.
	Few, 1-15 percent	2	43	11	4	2	62	Percent correct: 55.
	Widely scattered, 16-30 percent	0	7	22	19	4	52	
	Scattered, 31-45 percent	0	4	7	15	4	30	
	Numerous, >45 percent	0	0	1	11	15	27	
	Total	6	59	41	50	25	181	

and the number of times each term was used corresponds fairly well with the number of times it actually occurred.

6. CONCLUSIONS

The following specific conclusions may be drawn from this study:

1. There is no climatological difference in the areal distribution of showers and thunderstorms between the North and South portions of the State of Colorado.

2. There is a small, but significant, difference in the distributions in the East and West portions of the State.

3. There is a large and highly significant difference between the number of showers over the Mountain sectors and over the Lower Elevation sectors.

4. Defining forecast terms to describe the distribution of summertime showers by arbitrary equal intervals of percentage of stations (or percentage of area) affected by showers is a better procedure than to define the terms in such a way that they have an equal likelihood of occurrence.

5. Definition of terms by a class interval of 20 percent has certain advantages over the definitions using a class interval of 15 percent. While this conclusion is drawn from this specific study of Colorado, it is believed it is equally valid for other regions.

6. The forecasting terms "few widely scattered," "few scattered," and "widely scattered" apparently cannot be differentiated by the forecasters and therefore one term would suffice to describe the shower activity expected.

7. If the above three terms are designated by the one term "widely scattered," there are significant differences on the average among the distributions of the daily areal coverage of shower activity (daily percentages) for the most commonly used terms: "none," "few isolated," "widely scattered," and "scattered," where the only definitions of the terms are the general meanings of the words implying a progressively greater areal coverage of shower activity from "none" to some fairly high percentage. This strongly suggests that the forecasters are probably capable of differentiating between more strictly defined terms that would be more meaningful to everyone.

It is realized that there is always an element of uncertainty in generalizing too broadly from a specific study, but the following general conclusions seem appropriate:

1. Definite limits, or definitions, for *one* set of forecasting terms for summertime shower activity should be established and the forecaster should be aware of the relative frequency of occurrence of the terms in the area for which he is forecasting.

2. Once a set of definitions has been established studies should be made for individual States to try to relate various meteorological variables to the areal distribution of shower activity. Such studies would not, of course, solve the many problems involved in adequately describing the distribution of showers over an area, but would aid in placing the decision of which term to use on a more quantitative basis.

3. Once a set of definitions has been adopted, it should be thoroughly publicized so that the users of the forecast (the public) will know what a forecast means. Perhaps it is too optimistic to expect the public to become educated as to the meaning of the terms, but it is of equal importance that more precise definitions of terms be used so that the forecasters themselves know what a forecast means, and a more sound basis for verification is established. Improvement in forecasts can hardly be accomplished unless the forecasts are stated in terms that can be reasonably verified.

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